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Definition of mosquitoes and flies of the Families Blephariceridae, Deuterophlebiidae, Nymphomyiidae, and Rangomaramidae (Insecta: Diptera).

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The Blephariceromorpha is an infraorder of nematoceran flies, including three families associated with fast-flowing, high-mountain streams where larvae can be found. A recent classification based primarily on fossils divides this group into two infraorders and removes the Nymphomyiidae to their suborder, but this has not gained widespread acceptance. More recently, the family Blephariceridae has been considered a member of the infraorder Psychodomorpha, with Deuterophlebiidae and Nymphomyiidae assigned to their infraorders or left unassigned to the infraorder [1-3].

Family Blephariceridae

Blephariceridae is another cosmopolitan family of small mosquitoes, about 308 species in the world, 76 neotropical, they are called “net-winged midges”, because they have fine folds forming a delicate network between the alar veins. All species have aquatic larvae. The distribution of larvae is restricted to environments with fast currents, inhabiting rocky substrates directly exposed to running water, positioning themselves with their heads forward, in places where the flow can reach 1m/s (Figure 1) [4-5].

Figure 1. *Blepharicera beishanica* sp. nov. (male holotype). (**A**) habitus of male, lateral view. (**B**) thorax, dorsal view. (**C**) wing. Scale bars: 1.0 mm (**A**), 0.25 mm (**B**), 0.5 mm (**C**). Source: https://www.mdpi.com/2075-4450/13/9/794.

Blephariceridae feed on the biofilm formed by diatomaceous algae and other organic materials on the surface of rocks. Its appearance is unmistakable, with a flattened body, divided into six segments, each with a large ventral suction cup.

They move slowly, successively detaching their suction cups. The pupae develop in the same place where the larvae live. Adults of most species feed on nectar, but there are some predatory, insectivorous species [4-6].

The larvae have a series of adaptations to fast and turbulent areas that give them a peculiar appearance: the body is flattened dorsoventrally and the head (rounded and with exceptionally long antennae) precedes six segments equivalent to what would be the three thoracic segments and the first abdominal segment. Each of these segments has a pair of pointed pseudopodia in a lateral position which, in some species, are accompanied by pairs of small sensory rods that compensate for poor vision in turbulent waters (Figure 2) [6-7].

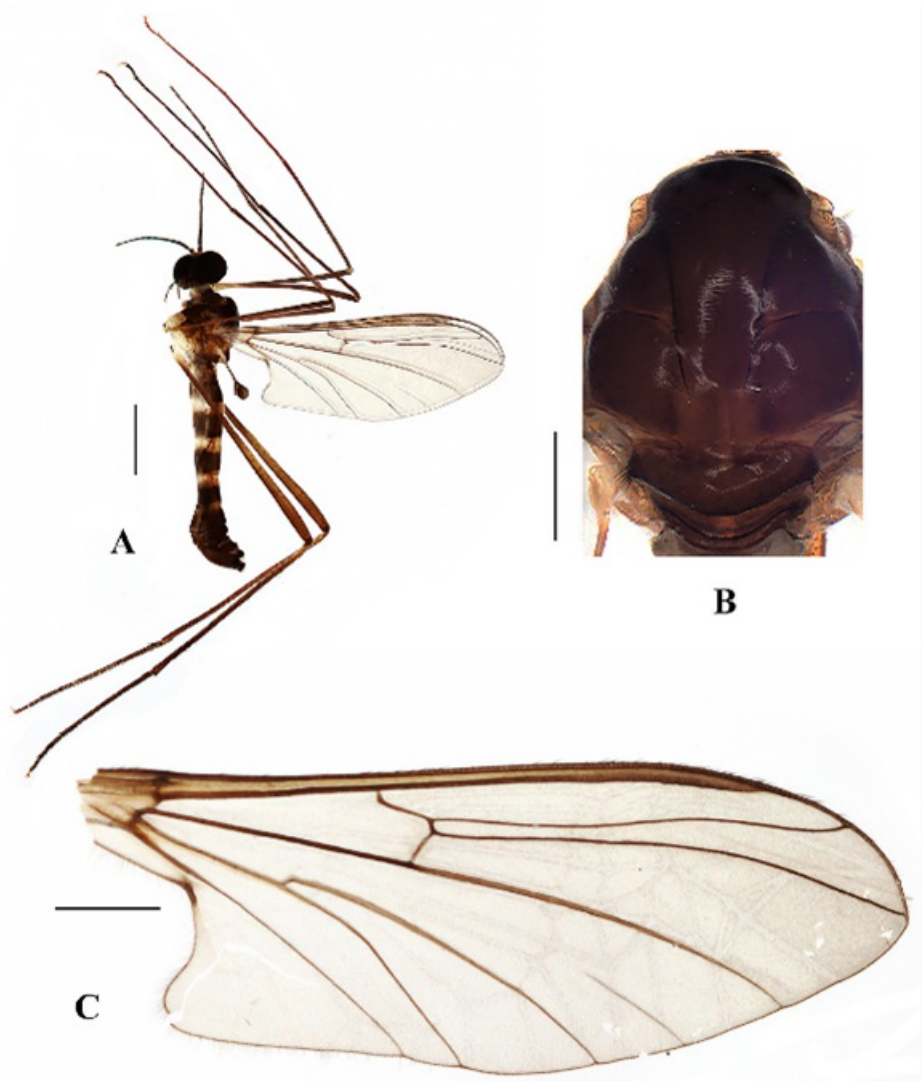

Figure 2. figs.1–2. *Blepharicera asiatica* (Brodsky) (male). 1. Habitus of male, lateral view; 2: Wing. Source: https://zenodo.org/record/226445.

Another unique characteristic of this family is the presence of adhesive suckers in a ventral position in the center of each of the post-cephalic segments, which helps them to move significantly in areas of very high current. The different segments are also equipped with pairs of trachebranch bundles to promote the uptake of dissolved oxygen [8-9].

The pupae adhere strongly to the substrate and also have a very distinct appearance. Adults are very similar to tipulids, but generally smaller, between 3 and 13 mm in length, with long legs, wings with reduced ribs and a network of folds in the intervening spaces, uniform coloring, and mouthparts, generally well developed in females. and reduced in males [10-11].

The pupal stage varies depending on the species and water current temperature but generally lasts between two and three weeks. Adult emergence requires the pupa to be well fixed to the substrate, can be very short, between 3 and 5 minutes, and occurs when the thoracic sutures are ruptured by the pressure of the legs and wings. This is when the adult emerges and reaches the surface surrounded by an air bubble (Figure 3) [10-11].

Figure 3. Eggs, larva and pupa of Blephariceridae.
Sources:https://www.ent.iastate.edu/dept/research/systematics/bleph/biology.html, https://www.landcareresearch.co.nz/tools-and-resources/identification/freshwater-invertebrates-guide/identification-guide-what-freshwater-invertebrate-is-this/no-jointed-legs/true-fly-larvae/midges/net-wing-midge-blephariceridae/ and https://bugguide.net/node/view/1407761.

The wings grow completely within the pupal envelope and are deployed only during emergence, allowing adults to fly immediately after reaching the surface of the water. Some species emerge at night or during dawn or dusk, although

many emerge primarily during the day [11-12].

Adults of most species live between one and two weeks, with male longevity being less than females. Mating usually occurs shortly after emergence and spawning consists of small clusters of eggs stuck to moist rocks. In some species, the female crawls underwater and lays her eggs on submerged rocks [12-13].

The larvae are mainly herbivores and with their highly specialized mouthparts, they feed on the thin layer of algae attached to the submerged rocks and also on bacteria and organic matter. Diatoms seem to be the main component of their diet [13-14].

The adults, females of many species are predators of other insects especially soft-bodied aquatic insects such as mayflies, Dixidae, chironomids, tipulids, mayflies, pearls, and other smaller blephariceridsٍ , while the males probably feed on the nectar of the flowers. Its distribution is limited by its requirements of cold, well-oxygenated, and very clean waters [13-14].

They are distributed on most continents except Antarctica) and on several islands such as Madagascar, New Zealand, Sri Lanka. Despite this wide distribution, regional endemism is high. The subfamily Edwardsininae is restricted to the southern hemisphere Australasia, southern South America, and Madagascar, while the subfamily Blepharicerinae is present in both hemispheres [15-17].

Classification

Subfamily Edwardsininae: In biology, a subfamily is the systematic unit between family and tribe. This level of classification is used to group the tribes of a particular family.

Genus *Edwardsina*, Meigen, 1803 (33 species in southern South America and southeastern Australia).

Genus *Paulianina* Paulian (1953) (8 species in Madagascar).

Subfamily Blepharicerinae: In biology, a subfamily is the systematic unit between family and tribe. This level of classification is used to group the tribes of a particular family.

Genus *Asthenia* Westwood, 1842 accepted as *Blepharicera* Macquart, 1843.

Genus *Liponevra* Agassiz, 1846 accepted as *Liponeura* Loew, 1844.

Genus *Sackeniella* Williston, 1896 accepted as Kelloggina Williston, 1907.

Genus *Snowia* Williston, 1893 accepted as *Kelloggina* Williston, 1907.

Genus *Tonnoirina* Edwards, 1929 accepted as *Edwardsina* Alexander, 1920 (Treated as valid subgenus).

Genus *Ablepharocera* Loew, 1877 (uncertain, unassessed).

Genus *Amika* (uncertain, unassessed).

Genus *Eupaulianina* Stuckenberg, 1959 (uncertain, unassessed).

Genus *Euphasopteryx* (uncertain, unassessed).

Genus *Metacurupira* Alexander, 1958 (uncertain, unassessed).

Genus *Nothohoraia* (uncertain, unassessed).

Genus *Paltostomopsis* Cockerell, 1915 (uncertain, unassessed).

Genus *Parablepharocera* Kitakami, 1931 (uncertain, unassessed).

Genus *Paracurupira* Tillyard, 1922 (uncertain, unassessed).

Genus *Philorites* Cockerell, 1908 (uncertain, unassessed).

Genus *Tianschanella* Brodskii, 1930 (uncertain, unassessed).

Genus *Astenia* Schiner, 1864 accepted as *Asthenia* Westwood, 1842 accepted as *Blepharicera* Macquart, 1843 (unaccepted > misspelling).

Genus *Asthenia* Rondani, 1856 accepted as *Asthenia* Westwood, 1842 accepted as *Blepharicera* Macquart, 1843 (unaccepted > unjustified emendation) (Figure 4) [17-20].

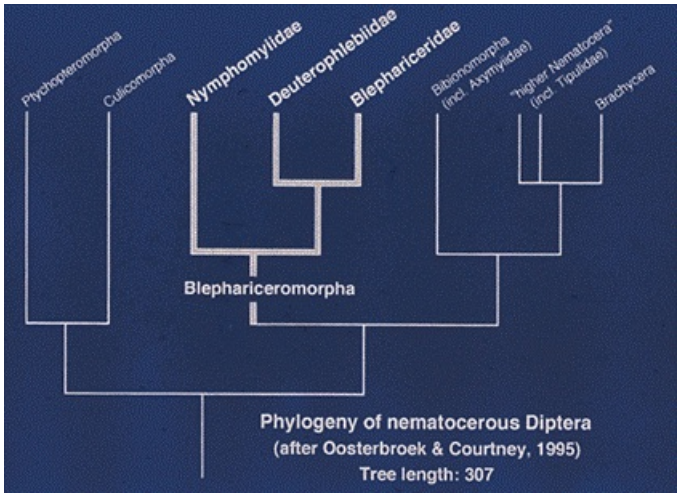

Figure 4. Evidence for monophyly of the superfamily Blephariceroidea (Deuterophlebiidae + Blephariceridae). Synapomorphies that help define this clade include features of the larva, pupa, and adult (details in Courtney 1991, Oosterbroek and Courtney 1995). Monophyly of the Blephariceridae is also well established and based largely on features of the larva and pupa. Source: https://www.ent.iastate.edu/dept/research/systematics/bleph/classification.html.

Family Deuterophlebiidae

The Blephariceromorpha are an infraorder of Nematocera flies. More recently, the family Blephariceridae has been

considered a member of the infraorder Psychodomorpha, with Deuterophlebiidae and Nymphomyiidae assigned to their infraorders or left unassigned to the infraorder. The location of these three families remains controversial [24-25].

The adults of Deuterophlebiidae are small insects, with a delicate body, about 3 mm long, and silvery-blue wings. The head is free, but hidden by the anterior projection of the thorax. Eyes well developed, ocelli absent. The antennae are composed of six thread-like articles and are generally much longer than the body, reaching lengths of nearly a centimeter in some species. The sides of the mouth are atrophic (Figure 5). [24-25].

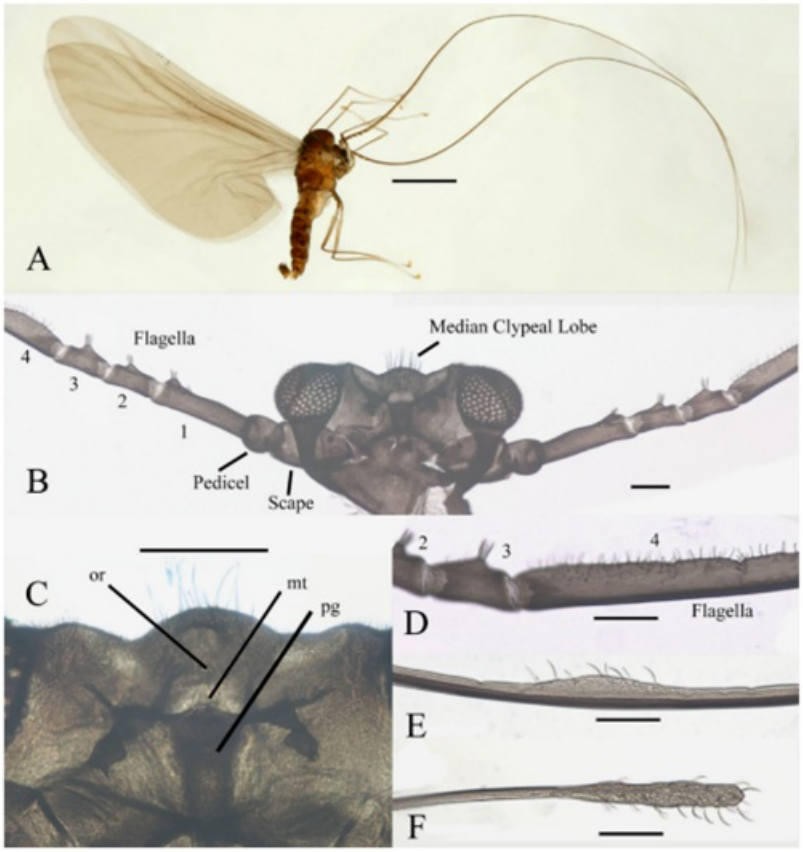

Figure 5. Male adult of *Deuterophlebia sinensis* sp. nov.: (**A**) male habitus (lateral view); (**B**) head (dorsal view); (**C**) oral region (ventral view); (**D**) flagellomeres; (**E**) middle part of terminal flagellomere; (**F**) apex of flagellomere IV. Abbreviation: or, oral region; mt, mental tooth; pg, postgena. Scale bars: (**A**) = 1.0 mm; (**B**–**F**) = 0.1 mm. Source: https://www.mdpi.com/2075-4450/13/7/593.

The thorax is short in Deuterophlebiidae and strongly convex, curving forward to hide the head. The legs are thin and noticeably elongated. The wings are particularly developed in length, maintained in a vertical position in the resting position. They have a very small rib and are replaced by a network of folds that develop longitudinally and transversely, simulating the grid of a fan. The abdomen is thin and elongated, wider in the proximal portions [24-25].

Post-embryonic development is holometabolic, with 4 larval stages and a pupal stage. The larvae are found in rocks

submerged by mountain streams and feed on algae, diatoms, and other microorganisms, whose colonies develop in these substrates, scraping them with their mouthparts. They also colonize streams that freeze in winter, avoiding streams that dry up at certain times of the year. The larvae do not adapt to extremely smooth surfaces, probably due to the different structure of the suckers (Figure 6).

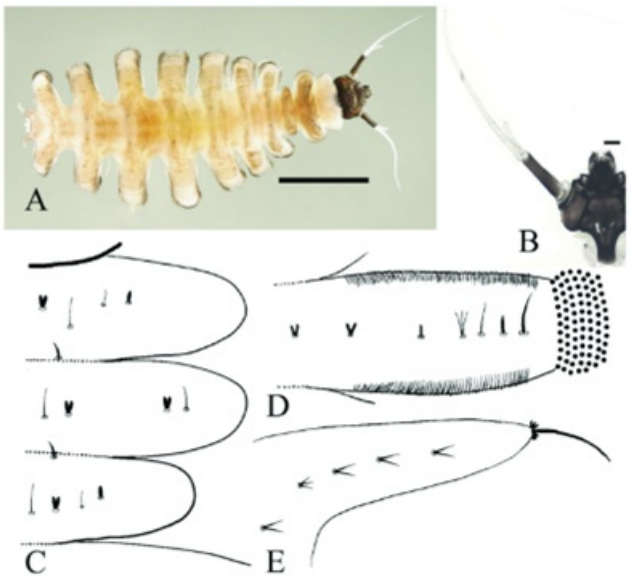

Figure 6. Larva of *Deuterophlebia yunnanensis* sp. nov.: (A) dorsal view; (B) head (dorsal view); (C) chaetotaxy of thorax (dorsal view); (D) chaetotaxy of proleg (dorsal view); (E) chaetotaxy of caudal appendage (dorsal view). Scale bars: (A) = 1.0 mm; (B) = 0.1 mm. Source: https://www.researchgate.net/figure/Larva-of-D-yunnanensis-sp-nov-A-dorsal-view-B-head-dorsal-view-C-chaetotaxy_fig7_361612825.

Pupation generally occurs in depressions or cavities, still attached to submerged rocks. The oscillation mechanism requires that the pupa is anchored to the substrate, as the adult causes the dorsal fissure of the pupal cuticle by exerting paw pressure on the substrate. The emergence occurs with different mechanisms in both sexes.

These insects have atrophic mouthparts and a rudimentary digestive system, therefore they are unable to feed and exploit the energy reserves accumulated during the larval stage. Consequently, their lives are very short: males probably live no more than 2-3 hours, while females live about 24 hours, the time needed to lay eggs after mating [24-26].

Deuterophlebiidae mating is related to the visual identification of males by females, and therefore environmental conditions regarding lighting and contrasts are of great importance. Males spend their energy reserves on the nuptial flight and mating, while females save energy, during the nuptial flight, to dedicate themselves to searching the location. Fertility is relatively low; each female probably lays 100 to 150 eggs. Another behavioral aspect associated with oviposition is the loss of wings. However, the submission mechanism is not certain: according to the female, she dives and deposits her eggs directly on the larvae's grazing sites [25-27].

The family has a limited distribution in the eastern Palaearctic region in the northwestern part of the eastern region and

the western Nearctic region, in typically mountainous habitats. This diffusion is fragmented into specific areas; this is because Deuterophlebiidae adults have a very short lifespan and limited dispersal ability, therefore a species is almost unable to expand its range into non-contiguous habitats [26-27].

Among the still unresolved issues of Diptera taxonomy, the evolutionary relationships of Nymphomyiidae, Blephariceridae, and Deuterophlebiidae have been debated for decades. These three families are included, by many authors, in a single grouping, that of Blephariceromorpha. In addition to some morphological similarities especially closer between Blephariceridae and Deuterophlebiidae, the common element is the habitat colonized by these insects. This would suggest evolutionary differentiations that led to the current families and a monophyletic character of Blephariceromorpha.

Some Species: *Deuterophlebia bicarbonate* Courtney 1994, *Deuterophlebia coloradensis* Pennak 1945, *Deuterophlebia inyoensis* Kennedy 1960, *Deuterophlebia mirabilis* Edwards 1922*, Deuteroflebia nielsoni* Kennedy 1958, *Deuterophlebia sajanica* Jedlicka & Halgos 1981, *Deuteroflebia shasta* Wirth 1951, *Deuterophlebia tyosenensis* Kitakami 1938, and *Deuterophlebia vernal*is Courtney 1990 [27-29].

Family Deuterophlebiidae (mountain mosquitoes). **Genus** *Deuterophlebia* Edwards, 1922. It has six North **American species**; Eight more in the Palearctic region. Aquatic larvae, attached to rocks in streams, with seven pairs of robust legs and long antennae. **Adults** with very wide wings, males with antennae much longer than the body.**Distribution:** Western North America; Palearctic region. **Habitat:** Deuterophlebiidae are generally considered stenobionts, requiring cold mountain streams; however, many species inhabit a diversity of stream types, from small, high-slope streams to large, low-slope rivers. The immature stages of all species are restricted to riffle habitats. where current velocities typically exceed 1 m/s.

In the absence of a mouth, adults cannot feed. Aquatic larvae. Individual adults are very short-lived, but emerge over a long period (at least in some populations); 1 to 4 generations per year. Some populations are parthenogenetic [30-31].

Family Nymphomyiidae

Blephariceromorpha have three families that are included in this infraorder, Blephariceridae, Deuterophlebiidae and Nymphomyiidae. Researchers suggest that Blephariceromorpha is a sister group to Psychodomorpha or Psychodomorpha + (Ptychopteromorpha + Culicomorpha). Another hypothesis is suggested, where this infraorder is suggested as a sister group to Bibionomorpha + (“higher Nematocera” + Brachycera) [34-37].

The Nymphomyiidae are a family of small, slender, delicate flies. Larvae are found among aquatic mosses in small, fast-moving streams in northern regions of the world, including northeastern North America, Japan, the Himalayas, and eastern Russia. The immature stages are aquatic and usually associated with moss in small, cool mountain streams. The non-feeding, short-lived adults die after copulation. Their simplified fringed wings can be shed at predetermined lines of fracture. Nymphomyiidae are neotenic, retaining various larval features. They have strap-like wings with a very reduced venation, and the wing margins have long fringes like those of the Thysanoptera (Figure 7) [34-37].

Figure 7. *Nymphomyth alba* Tokunaga, 1932, male. Source: Yuta Nakase and https://www.flickr.com/photos/yutanakase/16647700509.

Anthophyta or flowering plants did not appear until the Cretaceous around 140 million years ago so early Diptera did not have nectar from flowers as food. As many show a great attraction to the shiny droplets, it is thought that they may have fed on honeydew produced by homopteran insects such as aphids that were abundant at that time.

The mouthparts of Diptera are well adapted for licking and softening dried sweet residue. The basal clade of Diptera includes the Deuterophlebiidae and the enigmatic Nymphomyiidae (Figure 8) [34-37].

Figure 8. Larva - *Nymphomyia* Vermont, USA Source: https://bugguide.net/node/view/1009307.

Genus: *Nymphomyia* Tokunaga, 1932, *Nymphomyia alba* Tokunaga, 1932, *Nymphomyia brundini* (Kevan, 1970), *Nymphomyia dolichopeza* Courtney, 1994, *Nymphomyia holoptica* Courtney, 1994, Nymphomyia kaluginae Makarchenko, 2013, *Nymphomyia succina* Wagner, Hoffeins and Hoffeins, 2000 and † and *Nymphomyia walkeri* Ide, 1965.

According to ITIS 2013*:*

genus Palaeodipteron Ide, 1965. Specie: *Palaeodipteron walkeri* Ide, 1965 [34-37].

Family Rangomaramidae

Rangomaramidae is a family of flies in the suborder Nematocera e infraorder Bibionomorpha. The family, whose members are known as long-winged fungus gnats. Attributes: body symmetry, bilaterally symmetric, cellularity multicellular, development mode holometabolous, and feeding structure sucking mouthparts (Figure 9) [38-39].

Figure 9. *Rangomarama* (Jaschhof &. Didham 2002). Sources: Photo 2894331, (c) Stephen Thorpe and https://inaturalist.nz/photos/2894331.

The Rangomaramidae are small midges with a brown or yellowish-brown body, small, 2-6 mm long. The head has antennae of 16 articles, relatively large eyes, and ocelli, sometimes absent, three in number. The lateral ocelli, when present, are close to the margin of the eyes. The mouthparts have maxillary palps composed of 4 articles. The thorax is gibbous, and bears well-developed wings, long and relatively long and thin legs [38-41].

The latter have elongated cox bones and tibiae generally covered by a regular row of bristles. At the distal end of the tibia, there are one or two spurs. The spurs are generally less developed. The abdomen is relatively thin but to a lesser extent. The characters of the wing venation present some marked differentiations between the various genera; therefore, it is not possible to identify a truly representative model of the family. Common characteristics are the extension of the rib up to the apex of the wing, in correspondence with the confluence of R5, the division of the radius into two branches (R1 and R5), with complete absence of R4, the division of the media into two branches, M1 and M2 [38-41].

The family, members of which are known as long-winged fungus gnats, was erected. The Rangomaramidae (fungus gnat's) pest that adults and larvae that hatch from eggs oviposited in the ground by them also harm plants. In Brazil, this insect mainly damages ornamental plants and causes great damage to seedlings of different crops, such as citrus,

tobacco, strawberry, and others. Fungus gnats' mosquitoes can cause great damage, but indirectly. These mosquitoes can carry harmful pathogens, that is, they can carry and spread diseases to your plants (without roots the plant cannot absorb water or nutrients) [38-41].

Rangomaramidae-collection of the Zoology Museum of the University of São Paulo, Brazil

Family Rangomaramidae Jaschhof & Didham, 2002.

Subfamily Chiletrichinae Amorim & Rindal, 2007.

Genus Eratomyia Amorim & Rindal, 2007.

Eratomyia magnifica Amorim & Rindal, 2007.

Subfamily Chiletrichinae Amorim & Rindal, 2007.

Genus *Eratomyia* Amorim & Rindal, 2007.

Eratomyia magnifica Amorim & Rindal, 2007

Type locality: Ecuador, Quito Baeza, *E. Papallacta*. **Distribution:** Neotropical: Ecuador (Quito Baeza).

Eratomyia risaralda Amorim & Falaschi, 2010.

Type locality: Colombia, Risaralda SFF, Otún Quimbaya, El Molinillo. **Distribution**: Neotropical: Colombia (Risaralda).

Subfamily Ohakuneinae Amorim & Rindal, 2007.

Genus *Colonomyia* Colless, 1963.

Colonomyia brasiliana Amorim & Rindal 2007.

Type locality: Brazil, São Paulo, Salesópolis, Boracéia. **Distribution**: Neotropical: Brazil (São Paulo)

Colonomyia freemani Amorim & Rindal, 2007.

Type locality: Chile, Dalcahue, I. Chiloé. **Distribution:** Neotropical: Chile (Dalcahue).

List of species of Rangomaramidae from Argentina.

Subfamily Chiletrichinae Amorim & Rindal, 2007.

Chiletricha Chandler, 2002.

Chiletricha dureti Chandler, 2002. Chile (Linares, Fundo Molcho), Argentina. Nq.

Chiletricha equalis (Freeman, 1951). Chile (Chiloé, Castro, Malleco), Argentina. Nq.

Chiletricha freemani Chandler, 2002. Argentina (Nq: Pucará, Lanín National Park), Chile (Marga-loam).

Seminude chiletricha (Freeman, 1951). Chile (Chiloé, Ancud. Cautín, Osorno, Malleco), Argentina (Nq, Chu., T.F.).

Subfamily Ohakuneinae Amorim & Rindal, 2007.

Ohakuneinae Amorim & Rindal, 2007.

Colonomyia Colless, 1963.

Colonomyia magellanica Matile & Duret, 1994.Argentina (Nq: Pucará, Lanín National Park. T.F.), Chile (Chiloé, Llanquihue, Osorno, Malleco).

Colonomyia obtusistyla Matile & Duret, 1994. Argentina (Nq: Lanín National Park, Pucará), Chile (Llanquihue). Colonomyia sp. Amorim & Rindal, 2007. Argentina (R. N.), Chile (Magallanes).

Ohakunea Tonnoir & Edwards, 1927.

Ohakunea chilensis Freeman, 1951.Chile (L. Correntoso. Jaschho, Llanquihue, Dalcahue), Argentina (R.) [42].

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